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ABSTRACT

The conventional view of academic specialization is discussed, and the disciplines of biology and political science are used as illustrations. The analysis is based on literature studies concerning the two fields, interviews with five prominent persons in each field, and interviews with 32 biology and 32 political science faculty from 16 schools. Attention is directed to four patterns of integration. Since actual problems do not conveniently fall into disciplinary boundaries, scientists may have to study other disciplines to answer a specific question. In addition, methodologies or advances in instrumentation can sometimes integrate: a methodologist might need to search many fields to find the right problem to test a technique. The disciplines also reward individuals who look at a question from different perspectives (i.e., interdisciplinary approach). Finally, teaching integrates the discipline by forcing specialists to broaden their knowledge of areas beyond their own fields. For the future, it is recommended that research on disciplinary cultures be merged with studies of the growth of specialties. Also needed are studies on the way disciplines function in different organizational settings. (SW)

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SPECIALIZATIONS IN ACADEMIC DISCIPLINES: "SPOKES ON A WHEEL"

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Specializations in Academic Disciplines:

"Spokes on a Wheel"

Specialization is both a blessing and a curse for the academic profession. Without it, contemporary academe would find the enormous volume of knowledge hopelessly confusing and impossible to manage. The professoriate long ago abandoned its role of general tutor in favor of specialized scholar. (1) Under the burden of a combined obligation to create and disseminate knowledge, professors found specialization to be an inevitable strategy. It enabled them to cope with a more complex mission.

But it has a darker side. It is argued that specialization has become excessive. Academics in one discipline develop their own culture--their own intellectual orientations, styles of inquiry, objects of interest, heroes, attitudes, and procedural expectations. They become separated from other disciplines and often from other subfields within their own discipline. The scientific model is the basis for this outlook. According to the model, science advances linearly by building upon previous discoveries. But each discovery exacts a cost in the form of increased complexity: more categories of knowledge which are inherently narrower, more precise and rigorous, less "soft", and less able to address the overarching issues. Whether a curse or a blessing, an iron law of specialization controls the progress of science and similarly the academic profession.

This paper explores that tension by discussing the conventional view of specialization, raising some questions about it, and then examining the illustrative cases of biology and political science. There is indeed relentless specialization, but it does not necessarily follow that it

fragments the profession into a multitude of separate professions and sub-professions. For we find that the fragmenting forces generate countervailing integrating forces. A political scientist interviewed for this study offered a striking metaphor. Specializations within a discipline are like spokes on a wheel, separate from each other, but brought together by an outer ring. This paper charts the movements of scientists along the spokes and around the ring. Throughout the discussion is a concern with the concept of disciplinary culture and its importance for the study of higher education and the academic profession. Along with the organizational setting, the discipline shapes the professional life of an academic, but unfortunately we know far less about the discipline than we do about the institution.

The analysis relies upon several sources, including writings from the two disciplines; studies of their development; a series of background interviews with prominent members in each field; and another series of interviews with two members of the biology and political science departments in each of sixteen colleges and universities. The "elite" interviews (five in biology biology and five in political science) each lasted approximately one hour and addressed topics which pertained to the structure and culture of the disciplines. The individuals were chosen for their standing in the field as evidenced by indicators such as leadership positions in professional associations or editorship of journals. The other interviews (thirty-two political scientists and thirty-two biologists) each lasted an hour to an hour and a half but covered a broader array of topics including the individual's professional activities, research, teaching, and institutional obligations, as well as questions about the discipline. These individuals worked in institutions representing the several sectors of American higher education from community colleges to research universities. They also represented approximately an equal distribution of junior and senior faculty members. (2)

AN IRON LAW OF SPECIALIZATION

Specialization in the academic profession is inevitable. There are epistemological reasons: The sheer volume of knowledge and its rapid expansion compel a scientist to carve out his own niche of expertise. There are also sociological reasons: Academics achieve status within the profession by advancing knowledge, a dynamic that requires precise contributions. Institutions of higher education themselves compete for status, reinforcing the individual's motivation.

Understanding this process depends upon understanding the social processes in science. The scientific community operates according to a set of procedural "norms." These norms, first delineated by Robert Merton, assure scientific progress by providing scientists with a set of of guidelines whereby they offer their work to their peers, fully expecting it to be challenged and proven or disproven. This internal review mechanism ensures the integrity of science. Scientists make their findings available to the community, usually through publication, and fellow scientists are free to use those findings in their own research or to refute them. (3) Attention must be directed towards specific questions.

This pristine depiction of science has not gone unchallenged. One alternative view is that Mertonian norms might actually be "institutional fictions", verbal justifications for actions which reflect other motivations. The motivation which best explains the behavior of scientists is the commitment to a prevailing theory or methodology and the group's stake in a given set of principles surviving the onslaught of challenges. Proving a set of scientific beliefs false could have far-ranging repercussions for scientists who have invested careers and prestige in those beliefs, and it is probable, according to this perspective, that the defense of an existing set of theories actually becomes the "norm." (4)

If this portrayal of the disciplines sounds like an organization defending

its turf, if it sounds more like a game of bureaucratic politics than a description of an idealized view of science, it is perhaps because a scientific community can indeed be seen as a synthetic bureaucracy. It has a hierarchy, communication channels (journals, etc), maintenance and promotion mechanisms (professional associations), career patterns, and an environment. This also helps to explain the inevitability of specialization. The synthetic bureaucracy of the discipline divides its labor and specializes. It accommodates new challenges, but resists others, causing the rejected challenge to establish a competing synthetic bureaucracy. The political economy of disciplinary competition favors the proliferation of bureaucracies rather than monopolistic concentration.

The few studies of the growth of specialties confirm the importance of sociological factors. Studies of the "phage group" in biology and ethnomethodology in sociology showed that these specialties developed systematically in four stages--paradigm group; network; cluster; and specialty--each with successively greater social interaction among its followers. Within each of these stages is a patttern of social interaction that includes communications (serious discussion about the research); co-authorship (a more intense form of research communication); apprenticeship (the training of students); and colleagueship (working on a joint research project). As the specialty passes through its embryonic stages, it establishes the the basis for a "distinctive culture and normative structure." But when the mature specialty accelerates its intellectual production, it begins yet another division. According to Mullins, "Groups in this stage are too large and too spread for the immediate mechanisms of conversation and seminars to hold everyone to a dogmatic line...The impact of the real differences among intellectual biographies, as well as differences in skills and interest, should cause parts of the group to drift away." (5)

The forces behind specialization gained momentum when the modern

university embraced the positivism of modern science. It did so for a variety of reasons, but the first indication, in the American case, can be traced back to the late 1800s when research and graduate training were incorporated into the larger academic mission. Inspired by the German model, Johns Hopkins began its graduate program, while departments based on distinct subjects developed throughout higher education. Around that time Daniel Coit Gilliam referred to the "Temple of Science" and urged members of the academic community to contribute to its expansion by adding their own brick to the monument. With the temple's increasing grandeur, it became at once harder and easier to make a contribution--harder to make a noticeable contribution, but easier to find a little corner or imperfection that could stand improvement. This expectation of academic accomplishment endures even more strongly today. Survey after survey reveals that, although the overwhelming majority of academics perform little or no significant research, they still consider the most meritorious effort to be contributions to the discipline. (6)

But there is a disadvantage to specialization. In the view of some critics, specialization leads to isolation of subfields; and if disciplines advance by continually turning in on themselves, answering questions that are more and more specific, they may lose sight of the larger issues. Such was the warning of C. P. Snow when he lamented the rise of two intellectual cultures, the humanistic and the scientific, each unaware of the contributions of the other. (7) His simple dichotomy can easily expand into four categories: the humanities, the social sciences, the professional or applied, and the natural sciences, all of them so different in their attitudes and methods as to render interdisciplinary study problematic, if not impossible. (8) Recently, Tony Becher has considerably enriched our view of disciplinary cultures. Questioning the simplicity of Snow's scheme, he finds that disciplines are far more complex than Snow would have us believe; there are, in fact, strong subcultures within each of the disciplines. (9)

Another alleged disadvantage of specialization is the effect on the autonomy of the profession. The academic profession's expertise is, in some respects, the source of its autonomy. Because "only the holy can know what is holy," society depends upon experts to evaluate the work of other experts. Thus the more specialized the profession (the more inaccessible its work to the non-professional) the more society depends on self-regulation. But there does seem to be a threshold, past which specialization can detract from a profession's independence. Academics rely upon society for their resources, and under a system of autonomy the precise allocation of those resources would be left to the profession. But as the profession divides into separate cultures, it becomes increasingly difficult to determine the relative worth of efforts within each of the fields and hence difficult for the profession to make general assessments across the fields. A similar process occurs in science. Society makes a portion of its resources available to science, but it must retain the decision how to disburse the funds across fields: biologists cannot evaluate physicists; political scientists do not understand the advances in chemistry. (10) Inability to make assessments across fields is the price of specialization and causes a forfeiture of some self-regulation.

Nevertheless, specialization prevails. The social processes in science and the extension of knowledge, the values of higher education institutions and the values of the profession, create an environment that necessitates specialization. The reasons are everywhere apparent, in both the institutional lives of academics and in their disciplines.

QUESTIONING THE IRON LAW

Such is the common wisdom, but it does not account for some contrary observations. From various quarters come the rudiments of a counter-hypothesis. The attack is not a frontal assault on the "iron law" and its corrolaries; it is instead a series of episodic skirmishes.

Exhibit one is from the natural and physical sciences. In its 1982 Annual Report to the Congress, the National Science Foundation referred to the "dissolution of disciplinary boundaries," which it attributed to the sophisticated instrumentation and methodologies that migrate across fields. NSF offered the following examples:

> (S)olid state physics has merged with materials science and with chemical engineering and computer science to produce new catalysts and microelectronic fabrication methods;...optics, solid state physics, and cellular biology have merged in the creation of flow cytometry for analyzing cell components;...robotics and neurobiology merge in their analysis of vision. Fundamental studies of how a smoothly flowing liquid becomes a turbulent one devolve into work in mathematics, in physiology, in the dynamics of the atmosphere, and in galactic structure. The search to uncover the structure of cell receptors needs the recombinant DNA techniques of molecular biology. And fundamental work in receptor biology has in turn sparked the discovery of peptide receptors governing neurological events. (11)

Exhibit two comes from the social sciences. Clifford Geertz surveyed the landscape of the social sciences and found perceptible changes in the topography. He noticed the "blurring of genres." Those who study social issues no longer feel confined to disciplinary boundaries. Freed from the obligation to be "taxonimically upstanding," they can roam the disciplinary worlds, choosing from among the many different approaches. These journeys are not embarked upon simply to enjoy the exotic settings of other cultures; they are frequently necessary for scientific progress. Philology illustrates the point. The study of a people's language and literature has evolved into numerous specialties. These fall into the two general categories of those who study the text itself (the "softer", humanistic philologists) and those who study the social contexts of the act of inscription (the "harder", scientific approach). The gulf between the two became so vast that the study of the texts no longer utilized the sophisticated concepts pertaining to the social context; on the other hand, the study of the social context no longer considered the text itself. Becker, a philologist, writes that the discipline

responded to this split by creating a "new philologist"--a specialist to bridge the specialties.

> In a multicultural world, a world of multiple epistemologies, there is a need for a new philologist--a specialist in contextual relations--in all areas of knowledge in which text-building...is a central activity: literature, history, law, music, politics, psychology, trade, even war and peace. (12)

As walls between disciplines and subdisciplines become higher and harder to scale, there are an increasing number of mechanisms for cutting through them. Just as there is an iron law of specialization, so is there a tendency for areas of knowledge to attach themselves to other areas, contributing to advances in other fields and drawing from them.

Biology and political science provide examples of this tendency and an analysis of those disciplines reveals four patterns of integration. First, actual problems do not conveniently fall into disciplinary boundaries. To answer a given question, scientists often migrate across boundaries and draw from neighboring disciplines or subdisciplines. Second, methodologies or advances in instrumentation can sometimes integrate. Solving a problem in one area could depend upon a methodological breakthrough in another. In some cases, the methodologist, as a specialist, will wander from field to field searching for the right problem to test a technique. Third, the disciplines reward individuals who are "interdisciplinary" or who can look at a question from many different perspectives. Finally, the consumers of disciplinary research integrate. Only a small portion of the professoriate conducts research, but virtually the entire professoriate teaches and usually to students who do not need the level of sophistication necessary to forge new frontiers in the field. Students do need, however, a broad understanding of the field. Moreover, the teacher (because of institutional demands) must be swift on his intellectual feet, ready to move from an advanced class in

literary criticism, for example, to Shakespeare to remedial writing to introductory American literacure perhaps in the same day.

The first three patterns--problems, methodologies, and rewards--integrate the profession horizontially; that is, they operate across the subfields and occasionally across fields. Teaching, the fourth pattern, also integrates horizontally by requiring academics to leave the confines of their specialties. But it also (in principle) integrates vertically, establishing a link between the producers of disciplinary research and the consumers. This vertical link, as will be seen, is under some stress. As disciplines become more complex, and as the institutional sectors of postsecondary education in the United States become more stratified and distinct from each other, the consumers see the disciplines moving farther away from their concerns and needs. To anticipate a conclusion, the interaction of disciplinary and organizational cultures raises important questions about the fragmentation of the profession.

In the text which follows, quotations from the interviews are not attributed to an individual. When it is pertinent, I have identified the type of institution where the professor works; the discipline is usually evident from the context. The elite respondents are distinguished from the regular respondents by an asterisk. Referenced quotations come from documents or published works.

THE PATTERNS OF INTEGRATION

1. PROBLEMS

Modern biology traces its ancestry to Charles Darwin, but it owes one of its early advances to mathematically inclined individuals enraptured by the study of eugenics. Using their quantitative skills to tabulate certain

characteristics of the population, and intrigued by the potential of the nascent study of genetics to improve the stock of the human race, they not only raised controversial questions about the course of life sciences but also developed many of the probability measures now commonly found in nearly all sciences. Arthur Pearson (of Pearson product-moment coefficient fame) was an early eugenecist. So was Francis Galton, the father of regression analysis, who first used the technique to solve a problem in eugenics. (13) Biology remains derivative: "It is based in all science: math, chemistry and physics. A good biologist needs training in all those areas."*

Past is prologue in biology. Perhaps the most significant contemporary discovery was deciphering the DNA code, which led to even further insights into how cells reproduce themselves into definite forms. The problem was solved only after extensive migration of physicists and chemists to the field. One analysis of the research found that between 1945 and 1966 seventeen of the forty-one scientists in the "phage group" (a community of scholars working on the topic) were physicists and chemists. The migration of physicists was apparently a deliberate decision: They had concluded that "biology had the greatest number of unsolved problems which appeared open to fruitful investigation by physical methods" and that "physics would provide no interesting research for some time." (14)

To follow the paths of these immigrants it is useful to have a map of the discipline, but unfortunately it is impossible to construct one that all biologists would accept. There is the crude, almost passe, division between animals and plants. There are also the more analytical categories of observers (taxonimists and those who work in the field) and experimenters (the manipulators more at home in the laboratory). Such a classification is not without an implicit status connotation and for that reason is resisted by the observers. Usually, however, biologists today refer to levels of analysis in describing the structure of the discipline. The basic unit is the cell;

moving up the scale in complexity are tissues, systems, organs, organisms, and populations. Each level introduces a greater number of variables, less precision and predictability, and less of an opportunity to experiment. Recently this scale has expanded downward. Scientists have discovered that parts of the cell have complex properties especially useful in understanding the immune system and diseases such as cancer. For some "submolecular biologists", the cell is not specific enough.

This tidy morphology is deceiving because the discipline is so fragmented and the subfields so diverse that those who study some portion of the field are reluctant to identify themselves as biologists. They prefer specific titles such as immunologist, biochemist, or ecologist. (15) "I would like to be called a biologist," one respondent lamented, "but I can't in good conscience call myself that anymore because the field is too large." To add to the complexity, the boundaries of subfields are difficult to discern. Another respondent said, "When people ask me what is my discipline, I usually say immunology, because that's my area of research. But I coordinate a cell biology course and I am really a cell biologist. I study how cells function and those are problems that go beyond immunology...We also do a lot of genetics." Describing biology as a single discipline is therefore a convenience that can mislead. It is instead a collection of subdisciplines with different perspectives and attitudes. Those who study evolutionary processes, for example, are "historical" and concerned with broad developments of species or systems. "You can do molecular biology without asking those questions and you can actually do evolutionary types of studies without having to know a great deal about molecules or chemicals." Compared to other scientists, biologists "have the worst case of splinteritis...and it is very rough on them because they lose their coherence, they lose their interchange. When they develop a specialty, immediately they want to splinter off."*

Despite this extreme differentiation, or perhaps because of it, biologists

find their way through the borders of neighboring fields, usually motivated by the drive to answer a particular question but unable to do so with the information from their own narrow subfield. Studies of the growth of science support this view. Mulkay identifies numerous instances of "cross-fertilization" which he defines as "the interplay of divergent cognitive frameworks." And studies of psychoanalysis and bacteriology demonstrated that the need to answer practical questions was largely responsible for the birth of the new fields. Joseph Ben-David states:

> The practitioner-scientists appear as forerunners, supporters, and disciples in the history of the two innovations bacteriology and psychoanalysis. The central figures in both were "role hybrids" who were led to the innovation by an abrupt change from theoretical to applied science. The practioner-scientists, as well as the role-hybrid, each are in a position to shift frames of reference relatively easily. (16)

In the contemporary university in the United States, particularly in the biological sciences, the catalyst that causes researchers to solve practical questions can come from nonacademic patrons such as government agencies agencies. The growth of sponsored research and the ties between government patrons and academics are developments that have already been extensively analyzed. They have greatly affected the structure of academic science and the governance of research universities. The academic acquired a more complicated role in the institution, was torn by competing loyalties, and received a new source of power. (17) On the other hand, the ability to obtain research grants has become an important measure of professional success for the academic and a criterion in the hiring, tenure, and promotion processes. For an academic in a leading biology department or a in a department aspiring to be among the leaders, external support for research is virtually mandatory.

But funding agencies have objectives which supercede the preservation of

disciplinary boundaries. They seek benefits, and the more measurable and tangible the benefits the better the agency's chances of surviving in the political marketplace. For example, since its inception during the past World War II era of rapid growth in science, the National Institutes of Health has contributed enormous sums of money to academic science. In 1981, nearly 28% of the life scientists in higher education received NIH support. (18) According to James Shannon in a discussion of the agency's history:

> ...Federal support for research is purpose-oriented. Though the NIH supports a large number of individual basic science projects, this support stems from an assessment of the present state of biomedical knowledge and an estimate of the best mix of fundamental, applied and developmental research that is likely required in the solution of a number of biological-medical problems...There is no doubt that federal support for the expanding research program depended upon expectation of tangible medical benefits to be received. (19)

The point is not that the pursuit of "tangible benefits" has desecrated basic research, though the definition of basic research has undoubtedly become more complicated and now often includes modifiers such as "mission oriented." Instead, the point is that a problem, whether defined by the members of a discipline or by a coalition of scientists and their patrons, can force "cross-fertilization." The most dramatic contemporary example is the crusade to cure cancer which, because of the availability of research funds, has attracted scientists from across the spectrum of the biological sciences.

In contrast to biology, political science is not greatly influenced by research funds. Only 14% of the social scientists in academia receive federal support. (20) But the desire to solve problems for nonacademic constituencies still on occasion integrates the fragmented subfields.

The process is more complicated than in biology, perhaps because of the amorphous nature of the study of politics. As Dwight Waldo has written, both

the adjective "political" and the noun "science" have been problematic throughout the course of the discipline's history. (21) "Political" is problematic because "it encompasses a wide variety of approaches...you can study almost anything under political science. That means you can have two people who are called political scientists who can almost not talk to one another because what they do is so different." In any single department, one professor "could be working on Thomas Aquinas and the next on municipal elections in Buffalo." The methods--the science--are as varied as the subjects. For a political philosopher or someone who studies law in the classical manner, argument and the grappling with values are fundamental to their inquiry. They write books rather than scientific reports and claim their work is as much a "literary activity" as a scientific one; for one respondent, "insight and prose are so bound up, I wouldn't know how to separate them." Other political scientists, especially those trained during the "behavioral revolution" period of the 1950s, 1960s and early 1970s, compose crisp, mathematically enriched articles. Journals reflect this diversity. Some are known for highly quantitative articles comprehensible to a small number of specialists; others publish interpretive analyses that employ a variety of perspectives.

Although the range of subjects and approaches encompassed under the term "politics" is broad, nearly everyone agrees on the general contours of the discipline. There are four subfields: American government; international relations; comparative government; and political theory or philosophy. Depending on one's perspective, public administration, public policy, and public law constitute separate subfields or are parts of American government. Increasingly, methodology also is seen as a separate subfield.

These fields serve as identities for political scientists and it rarely happens that someone cannot claim one as his primary interest. But the organization of political science into four fields does not adequately

describe the intellectual work in the discipline. It is a convenience that provides continuity and administrative simplicity. The structure is imposed from "the top down". It refects the "way the American Political Science Review arranges its book review section" or the way academic departments organize themselves. Issues of power and standing within the discipline or a department--for example a hiring or curriculum decision--are often couched in terms of one subfield's interests against another's. And when the American Political Science Association suffered a 25% drop in membership between 1972 and 1982 it blamed it on the desire of some political scientists to join other associations more compatible with their specific interests. Political Science, as a discipline and as a departmental entity within the university, has thus used a form of "corporatism" to cope with its diversity, if corporatism is defined as allowing each interest to govern itself within its own sphere of expertise. "The department where there is harmony is typically a department in which each subdiscipline is permitted to do what it wants because if there is an effort to try and apply some uniform criteria that is just going to lead high conflict."* In a discipline where there is disagreement about methodology and the legitimacy of one approach or another "and where it is hard to know who is doing path breaking work across the fields," the solution is to allow each subfield to set its own standard, to use the subfields as a way of bringing social order to a discipline, but not necessarily as a way to describe the intellectual endeavors.

So if a political scientist can easily identify his subfield, it is not as easy to categorize a particular idea or piece of research. Work conducted by political scientists will frequently draw from a number of perspectives. One respondent, after describing the structure of the field, said that the categories should be seen "much more in terms of an over-arching institutional structure that influences the way people communicate with one another than it does influence research...The research is cutting across" the subfields. But

then he added:

> What I'm talking about should not be seen as something that's putting everybody in communication with one another; it's not that kind of thing at all. Instead, what's happening is that very distinct groups of communicators are growing up. You see them recognized in the semi-official structure of the discipline. The political economy group; people who study executives and administration...A new group on political literature is being started by someone in American politics and draws together people in political theory, comparative, and some at large.

Perhaps the most significant bridge-building exercise has been public policy studies. During the "behaviorial revolution," the period when political scientists armed with powerful mathematical tools became enamored with raising the level of rigor in the discipline, attitudes about the discipline changed. Students of politics tried to develop and verify theories of political behavior that would separate the discipline's historical preoccupation with value questions from the facts that should constitute a true science. As this movement reached its peak in the late 1960s it ran head on into the turmoil of the Vietnam protests, student demands for relevance, and a reaction on the part of some political scientists against what they perceived to be the dismissal of value questions from political inquiry. Relevance and involvement were the battle cries of the reaction. In a presidential address to the American Political Science Association in 1969, David Easton labeled this a post-behavioral revolution which "encouraged a new norm of behavior," namely, "policy engagement as a social responsibility of the intellectual." (22)

The development of policy studies as a distinct, integrative subfield is the result of a number of developments, including the importing of techniques and theories from economics, operations research, and other pockets of the

social sciences. But there is no denying that the appeal of policy studies is the blend of rigor (a carryover from the "scientific" behavioral revolution) with usefullness and application (a vestige of the "normative" post-behavioral revolution). With some justification, critics contend that promise exceeded reality; policy studies proved neither rigorous nor influential in the formation of public programs. And policy studies is further criticized for fragmenting rather than integrating the discipline. Policy students coalesce around policies, such as defense, the environment, energy, or education, and do not generally try to develop overarching theories of politics. Nevertheless, in a recent reorganization of the American Political Science Association into sections, the policy section emerged as the second largest, and it is likely that its membership consists of individuals from a variety of subfields whose primary allegiance remains with a traditional subfield; if so, this would simply confirm the integrative function of policy studies.

In both biology and political science, two disciplines wracked by specialization and fragmentation, the need to answer problems provides one catalyst for migrations across the subfields. The terrains of the disciplines differ; their professional associations have different levels of concentration; and the organization of their subfields are different. These factors may affect the rate or form of cross-fertilization but they do not eliminate it.

2. Methods

When searching for solutions to problems, individuals moving among the subfields are aided by methodologies which are not specific to any one topic. Methodologies are languages that most specialties can understand.

In biology the technique used in recombinant DNA experiments is the most striking example. Biologists have discovered the means to separate and recombine strands of DNA, thus altering the fundamental genetic code of a

cell. Because DNA is found in all species--plants and animals--the technology of gene splicing provides a link between botanists and zoologists. "Fields converge if you use the technology available," according to one informant. Another said that gene splicing also provided a common ground for the taxonomists and the experimenters: "Looking at structures of genes is going to open a whole new area in...comparing species for relatedness or lack thereof, and the tools for doing that are just enormously more powerful."

One indicator of the integrating ability of methodological developments is that it is easier to switch subfields in biology than it was fifteen years ago. According to one biologist:

> Now you can take gene cloning techniques from one sub-discipline to another. You can apply them to animals and plants and ask many of the same questions... What you find is that a lot of people who have been trained in molecular biology and in the development of the these techniques jump around from one biological system to another. Some of these people are more technologists than biologists who operate with a question in mind and then take their systems and techniques to answer that question... I call it the band-wagon effect: they work on one problem and then something else turns up and a whole bunch will switch over to that and then over to the next one that comes up. I think that is fairly new.

The development of recombinant DNA technology has not redrawn the map of the discipline, but it has created avenues between the subfields. This has had a secondary impact on some academic departments. There have been painful reorganizations, such as the merging of botany and zoology departments. Or, as in one major research university, interdepartmental research units may arise. The reason, according to a molecular biologist, is "that successive waves of technology have passed through the sciences and have essentially homogenized whole blocks of departments so that my colleagues as molecular biologists are likely to be scattered throughout the university" in the medical school and the chemistry department, as well as as in the biology

department.

In political science the integrative effects of methodologies have not been as detectable. The scientific basis of the discipline is not as advanced as in the natural sciences and there is less agreement on what constitutes appropriate methods. Political scientists must have a "tolerance for ambiguity and a less scientific approach."* That notwithstanding, the behavioral revolution swept through nearly all the subfields. Knowledge of quantitative techniques is now routinely required for doctoral candidates; indeed, perhaps the only class that brings together all the graduate students in a department is the mandatory research methods.

Methodologies integrate political science in a more general way than they do in biology. Whereas recombinant DNA techniques cut through the biological subfields with some precision, the situation in political science has more to do with an increasingly consensual belief that attention to methodologies is imperative regardless of the substantive area. One of the reasons is that the discipline has no "recognizable periphery," in the words of Dwight Waldo. As mentioned before, the ambiguity of what constitutes "politics" invites a countless list of candidates for inquiry, so that the subjects of political science fragment the discipline.

> The interests and activities of political scientists move outward toward and become mingled with those of the other social sciences, with those of the other learned professions (especially law), with those of traditional intellectual endeavors (literature, philosophy, mathematics), with those of newer intellectual foci (system theory, computer technology, operations research), with those of politicians, publicists and journalists. Journals of considerable, perhaps even critical, value to political scientists run to several score. (23)

The "political" of political science usually acts centrifigually, pulling members of the discipline away from the core. But the behavioral revolution acted centripetally injecting into the discipline a model of logical

positivism, a devotion to the scientific method that lowered the status of descriptive-prescriptive studies and raised the status of studies that developed theories and concepts. Political scientists turned to quantitative techniques as a way of advancing the discipline. Regardless of the issue, studies had to be verifiable and reproducible, informed by theory and guided by standard procedures.

The victory won by the behavioralists was not complete. Political philosophers, who clung to their historical concern for values, and public administrationists, whose connections to the practice of government left them skeptical of abstract theoretical work, were two major groups that remained unconverted. Still, as measured by elections to association leadership positions and the direction of journal editorial policies, the influence of behavioralism was pervasive. The language of discipline had changed. "The use of statistical methods became more complex and sophisticated, mathematical and quasi-mathematical formulations were frequently used, and vocabularies became increasingly technical and esoteric. Even introductory textbooks came to reflect the new political science." (24)

This is not to say that attention to methodology united the field, only that it was mostly a centripetal force operating against the centrifugal pull of the numerous substantive concerns tolerated under the rubric of politics. Research procedures can still differ among subfields. Standards of good work are not always agreed upon within departments of political science, and disputes can readily erupt between members of subfields. But the language of statistics and quantitative techniques provides at the edges of the subfields "a translating capability that didn't used to be there."*

3. Rewards

Academics consider specialization to be an inevitable consequence of the expansion of knowledge, but a consequence not without its pernicious impact.

It limits the vision of researchers. To overcome this disadvantage, individuals must break through the boundaries. The integrator--the individual who can successfully incorporate the findings in several seemingly unconnected fields--accordingly obtains status among his peers. To the problem-solvers and the methodologists, we can add a third catalyst for integration: scientists liberated from the obligation to be "taxonimically upstanding" are among the most highly regarded by their peers. The search for prestige motivates integrative efforts.

When biologists and political scientists describe specialization, they do so negatively. It is, they suggest, the price of scientific progress, but one that must somehow be overcome by individuals who can connect the fragmented specialities. "Against the arteriosclerosis of too much disciplinary development," said one biologist, "is the antidote of fundamental intelligence of people recognizing something good when they see it...And the better prepared the individual is from a broad biological frame to recognize something good, the faster our science is going to advance."*

As specialties develop, they strain the social fabric of the discipline and reorganize the patterns of interaction among researchers. Association memberships are courted by numerous splinter organizations in competition for the allegiance of specialists. And journals, the communication networks of the disciplines, cannot cover the range of topics necessary to appeal to a broad constituency while continuing to publish articles sophisticated enough to qualify as contributions to the field. Academic markets are relentlessly segmented and continuously subdivided.

The associations are especially vulnerable to the pull from subfields. As organizations, their survival depends on sustaining and nurturing their memberships; paradoxically, their survival as learned associations depends on facilitating the advancement of knowledge, which can lead to further specialization. A political scientist described the plight of the student of

international politics.

> First, the World Politics Journal, The International Studies Quarterly and the Journal of Conflict Resolution are more useful and rewarding to read than the American Political Science Review (the journal of the American Political Science Association). Second, if you go to meetings of the International Studies Asociation you will find an abundance of riches. If you go to a meeting of the American Political Science Association, there may be only a handful of panels that meet your immediate interests. Third, it is easier to find your colleagues with similar interests in a more specialized meeting and to interact with them. So on grounds of simple cost-benefit analysis, the more specialized societies have a higher pay off.*

Journals face the same cross-pressures. The subfield of political philosophy illustrates why. Unlike other political scientists, political philosophers boast of a tradition of argument; in this respect, they resemble their brethren in philosophy and are the mavericks and gadflys in the dispassionate, "scientific" discipline of politics. In the opinion of some political philosophers, however, the specialty has become less argumentative in recent years, a development they fear will strike at the very heart of their form of inquiry. One reason for the decline of argument is that journals in the subfield have become extremely focused. The evaluation of proposed articles is confined to a closed network of peers sharing a similar outlook. "Straussian" journals circulate submissions among Straussians, for example, while Marxists journals send their submissions to Marxists, so that Marxists and Straussians seldom review each other's work. When the articles are submitted to the mainstream journals which cover a broader range of subjects, the Straussians and Marxists frequently "kill each other off" by critically reviewing submissions from the opposite perspective. The result is "well-established little cadres of people who don't argue anymore about how

political theory should be done." Perhaps political philosophy is an exceptionally obvious case, but similar processes most likely occur in other subfields as well.

Given these disadvantages to specialization, it is not surprising that academics regard synthesizing, integrating work more highly than any other form. This is difficult to verify conclusively and could stand a more systematic analysis. But when asked to describe "outstanding" members of their profession academics repeatedly mention those "who have contributed to systematic cross-cutting theory,...the conceptualizers who force us to look at things in more integrated ways across disciplines...(These people are) nearly always going to be up there in prestige." A highly regarded peer is someone who is "broad and well-read and able to bring knowledge from other disciplines to broaden the perspective within his own." "Landmark contributions" come from people who "are not drowned by a particular orthodoxy but having chosen a problem look at it from a number of points of view." To one political scientist, "The big deal stuff is from those who have attempted some relatively theoretical contribution to their field or the discipline as a whole." From comments such as these emerges a strong proposition (worthy of future study) that a normative model for academics includes an ability to overcome the confinement of specialties. Whether that respect is translated into tangible rewards of promotion remains to be confirmed, but because of the concern over excessive specialization, the integrator is at least accorded respect.

There is an important qualification. Integrating, synthesizing, and developing cross-cutting theories are not the same as intellectual dilletantism. Hopping from specialty to specialty, dabbling in each without making an important contribution in any--a jack of all academic trades--is not accorded prestige. On the contrary, those individuals are considered neither integrators or specialists, masters of neither breath or depth. In the

extreme, they are considered "charlatans". Textbook writing, for example, is not denigrated and can provide a healthy supplement to an individual's income, but the professional rewards are minimal. The true integrator addresses the professional community instead of the generalist audience. Translating the discipline for those outside the field is not "big-deal stuff." The distinction is important to bear in mind when discussing the teacher-consumer, the last of the four categories.

4. CONSUMERS & TEACHERS

Teaching integrates the discipline epistemologically by prying researchers out of their specialties and into the classroom where the audience demands less depth and more breadth. When a specialist breaks out of his area and is forced to "keep up" in related areas, new insights occasionally emerge. The dissemination of knowledge might lead to the creation of knowledge, a reversal of the hypothesis that research contributes to teaching.

It is also argued that teaching integrates the profession socially because it is one common activity of academics. Professors who perform little or no research--the consumers in the discipline--join with the producers across the sectors of higher education to present the products of the discipline to a nonspecialized audience. With a wider variety and a greater number of courses to teach, the teaching professoriate must maintain a general knowledge of the discipline. According to this view, consumers and producers constitute a simple division of labor in the discipline, not a fundamental fragmentation.

Interviews with academics provide numerous examples of teaching contributing to the production of knowledge; they also reveal a belief that teaching prevents an individual from becoming preoccupied with a speciality. But they do not provide much evidence that teaching integrates the profession across sectors. The differences among institutions and the diverging "teaching contexts" have led the teaching profesoriate--the consumers--to feel

increasingly removed from the discipline. The organizational settings interact with the disciplines in a manner which raises doubt about the potential of teaching to integrate vertically.

The argument that teaching can lead to advancements in science is certainly not new. Sociologists of science frequently cite the case of the floppy-eared rabbits, a novel comparison of different research styles. Two scientists, operating independently, discovered that rabbits injected with substance papain developed floppy-ears. The injections were performed for reasons other than changing the posture of the ears, so the floppiness was an unintended but perhaps significant result that required an explanation. The first scientist, whose expertise was the study of muscles, thought cartilage was inert tissue and could not determine the cause of the change. The second scientist experienced "positive serendipity" one day while demonstrating a procedure to his pathology class. To demonstrate the procedure, he compared sections of the floppy ears with sections of the normal ears. This caused him to notice a change in the matrix of cartilage, which he later traced to the effect of popain. Approaching the problem as a teacher of pathology, the second scientist found connections missed by the first.(25)

While the case of the floppy-eared rabbits could be unusual, academics at least believe that teaching sometimes overcomes the confinement of a specialization. A molecular biolgist with a demanding teaching load considered himself "better prepared to ask interesting questions about membrane chemistry because I am forced to keep up with a pretty wide area." One leading biologist in a major research university favorably compared his setting to a medical school or a research institute where the attention to a problem is more intense, but where "there is little chance to broaden perspectives and interact with diverse areas of biological sciences. The paradigms are so well established in a field that it is very difficult to come up with a new paradigm; but sometimes by teaching all the different paradigms

you become aware of things that have popped up that you wouldn't have noticed otherwise."

Although teaching integrates the disciplines horizontally across the subfields, it is less successful in integrating the profession vertically, up and down the institutional sectors of higher education. Postsecondary institutions in the United States are extremely diverse and the missions distinct. These organizational settings and institutional imperatives interact with the disciplines and generate different "teaching contexts" across the sectors. The result is that the "consumers" feel less a part of their disciplinary profession. On a general level some link of course remains across the sectors; appearing in front of a class is indeed an activity performed by all academics regardless of their organizational setting. But on another level the teaching contexts are so different that the bond becomes weaker and more tenuous.

The dynamic is complex. At the risk of oversimplification, there are two categories of variables to consider. One is the nature of the particular discipline, its epistemological and social structure. The second is the nature of the organization, its size and mission. The interaction of the these two variables determines the strength of the disciplinary link across sectors of higher education.

The nature of the discipline includes its epistemological and social characteristics. In biology, for example, research is usually conducted by teams. Biologists establish labs, hire graduate students and postdoctoral scientists, and build small enterprises to perform their research; all of these conditions might not be necessary to conduct biological research, but they constitute the norm. And the professional associations and conferences have their distinctive characteristics. As already noted, biology has a multitude of associations, and although some of them meet jointly, the conferences tend to focus on specialized subfields. Also, the biological

sciences are enjoying enormous strides in the understanding of biological processes; as one biologist said, "Most of what I am teaching now I was never exposed to as a student; let us say 60%."

These conditions place great stress on the consumer of biological research. At one extreme is the community college instructor. One Ph.D. biologist spoke of her activity in a recently formed statewide assocation for community college biologists. She welcomed the birth of the association because she felt uncomfortable at the major assocations' conferences. "The technology is new and I am out of it," she explained, "You can pick up every fifth word of what is said at some of the lectures." The purpose of the new association was "for the exchange of ideas among people who have the same problem...If you go to these high powered meetings, you can bring almost nothing to the students, but from the meetings of the new association I bring back a lot because they are geared to the teacher of the two year institution." She readily admitted a break with her field: "Definitely I am out of the scholastic end of it, the research, the high powered end of it. I have given up on that and I have come to terms with it."

The situation is different for a biologist at a small four-year college who wishes to perform some research. There the difficulty "is that you couldn't talk to anyone; there would be one biochemist, one ornithologist, and one botanist, and it didn't work." The size of the departments and the teaching demands leave two strategies for the small college biologist. One is to do "horizontal research" across disciplines and subdisciplines. This would contrast with the highly specialized "vertical" research performed by scientists at leading research universities. Another is to organize the department to "try and do a few things well...Large and small universities should be doing things on the same plane but necessarily the small college will have to pick and choose what it does." Regardless of the strategy the tension between disciplinary and institutional imperatives is never completely

resolved.

Political science faces similar pressures, but it is a different discipline and its interaction with the organization yields slightly different responses. The community college instructor again feels the most removed from the field. One instructor who held a doctorate in the discipline discontinued all activities in the primary professional association. He explained:

> There was such a disparity between what they were doing and what I was doing that I didn't find it to be terribly intellectually stimulating....The major difference I think is the far more esoteric approach towards the discipline...Given where my students are at and where they are likely to go; given their socio-economic backgrounds and language limitations, a lot of the things I see in the journals don't correspond very much to what I can do in class.

At a small four year college some political scientists will continue to do research, but it could be very different from that found at a major research university. There is less concern with "carving out a niche in the profession." One small college political scientist admitted that his work, while greatly rewarded by the institution, was not "highly fashionable in political science"; his present setting allowed him, in his words, "to follow precisely where my curiousities led without having to answer to anybody or feel that I was professionally imperilling myself." For these individuals, the discipline is a touchstone and research is important, but contributing to the discipline is not a primary objective.

Political science differs from biology in another perhaps more subtle way. Political science below the graduate level is a kind of service discipline. On the undergraduate level there are significant numbers of political science majors and the transmittal of the discipline is important to a certain extent, but only a few students plan to be political scientists and the connection between their education and later career plans is often indirect. Besides conveying the discipline, political science courses are

therefore concerned with other objectives such as citizenship, contemporary public affairs, and the like. In contrast, biology students are more likely to enter scientific careers and the connection between coursework and later careers is more direct. In other words, the pedagogy of political science can be separated from its scientific base more readily than in biology. If this is true, then the difference between graduate and undergraduate political science is greater than the difference between graduate and undergraduate biology. If so, the difference between those who teach mostly undergraduates and those who teach mostly graduates might be greater in political science than in biology. In both disciplines, however, teaching and research contexts across the sectors differ to a degree that weakens the disciplinary bond among academics.

Organizations have distinctive cultures. So do the different disciplines. The enterprise of higher education is perhaps unique in its overlaying of the two different kinds of cultures. The implications for the academic profession are significant. It is commonly believed that one of the strongest bonds within the professoriate across the institutional sectors is the discipline, but if the "teaching contexts" become so different that the disciplines look different across the organizations, then the bond, although not yet broken, is weakened. Teaching still seems to horizontally integrate academics from different subdisciplinary settings, but its ability to vertically integrate academics from different organizational sectors appears in jeapordy.

CONCLUSIONS

Rather than repeat the observations already made, this final section sets forth a few considerations for future research. The structure of disciplines, their social context, and their importance in understanding the profession are complex subjects and by no means the easiest to investigate. A few suggestions follow.

1. The rate of convergence and divergence in the disciplines depends upon the epistemological structure of the discipline. The "terrain" of the discipline--the distance between the subfields and the height of the barriers--determines the extent to which migration occurs across fields. Also significant are the history of the discipline, the strength of its paradigms, and the status of it methodologies. The ability of one subfield to translate developments for other subfields, something that can usually be accomplished with methodologies and an understanding of the various paradigms in contention, can certainly affect the rate of integration. The rate is also affected by the discipline's social structure. For example, the organization of professional associations and departments determines the likelihood of scientists coming into contact with each other and sets the standards for professionally acceptable work.

The social and epistemological structures also determine which patterns of convergence prevail. The importance a field places on certain problems, the development of methodologies, the nature of work that is accorded prestige, and the vertical integration of the discipline (the intensity of the relationship between producers and consumers) all depend on the culture of the particular discipline.

Although there is some research on the culture of disciplines and on the development of specialties, the volume of the literature is not commensurate with the importance of the topic. It would be considerably useful to merge research on disciplinary cultures with studies of the growth of specialties to determine how certain features of the discipline affect the rate and form of convergence.

2. Disciplines and organizations interact. Not all disciplines are organized the same; the social and epistemological structures vary considerably. Organizations also vary--in their missions, structures, interaction with the environment, and clientele, to name just a few of the ways. The academic

profession defines its existence by the interaction of organizations and disciplines, but most previous studies have focused on either the institution or the discipline. Therefore we know very little about which characteristics of the disciplines adapt or do not adapt to particular organizational settings. One can imagine a set of variables derived from the organizational culture placed alongside a set of variables derived from the disciplinary culture. The interaction between the two sets could be instructive about the nature of the academic profession in a system as heterogeneous as the United States.

It might also guide the formation of institutional policy. Complaints are constantly heard from one department that the demands placed upon it are inequitable compared to those in another department; that the teaching and research imperatives are not comparable across departments. Decentralized decisions are an effective way of coping with this dilemma; during tenure decisions, for example, great weight is usually placed upon the department's assessment of a candidate. But as higher education becomes more hierarchical and influenced by governing systems beyond the immediate campus, "bottom-up" decisions become less frequent. In the absence of a consensus about the proper managing style, better information about the professional demands of the discipline--and the extent to which they differ--could be useful in informing institutional policy that is "top-down."

3. On a number of dimensions, biology and political science are extremely different disciplines. Their paradigmatic structures are different. Their professional associations are organized along different lines: biology's are more numerous and confederated; political science remains comparatively centralized under the "corporate" governing structure of one primary association. The maps of the disciplines also differ. Biology is more complex and the labels--the localities--more numerous. Political science's localities are fewer, but within them are a multitude of

neighborhoods. Finally, the departmental structures of biology vary considerably, whereas political science is virtually always found in a single department.

Biology and poltical science also differ in the "permeability of their boundaries," to borrow a phrase from Tony Becher. Biology's constantly increasing dependence on external funding, from both government and industry, is much different than political science's. And interaction with other disciplines may also be different in biology than political science, although the evidence for this is so far sketchy. Nevertheless, the influence of the environment could explain some of the patterns of convergence and divergence in disciplines. Further examinaton of these influences would be a welcome addition to the study of disciplines in the profession.

Despite these differences, biology and political science might not reflect all the variables worthy of consideration. Comparing the two disciplines was useful only for raising questions. Answers and greater refinement of the questions will have to await the study of other disciplines, such as those in the humanities and the "harder" physical sciences. The inclusion of professional areas, such as medicine and law, could also provide insights.

4. Finally, although this paper was not designed to test existing theories in the history, sociology, or philosophy of science, nor to examine the already over-examined work of Thomas Kuhn, the patterns of convergence in political science and biology do raise at least one pertinent issue. Kuhn, informed by a thorough understanding of the history of physics, speculated that fields of science dramatically change when an existing theory no longer adequately accounts for observations and when a new theory comes along that has greater explanatory power.(27) But it might also be the case that developments happen less dramatically; that changes in fields occur gradually as various specialties, constrained by an intellectual gridlock, find it impossible to

advance until another one moves. In such cases, specialties may look to others for assistance; they may borrow theories or methodologies and apply them to their own questions, experimenting (in effect) with alternative explanations. No new theory is developed. And knowledge may advance slowly, if at all. What might occur, however, is a reconfiguration of the subfields, one moving closer to the other. A crisis of specialization might therefore be temporarily or incrementally resolved without a "scientific revolution." New specialties might actually be coalitions of parts of other specialties. Social sciences almost certainly advance this way. And the biological sciences might also; one student of the historiography of biology claimed:

> Biology has proceeded not by great set-piece battles but by multiple small-scale encounters--guerilla actions--across a broad landscape. In biology, no large scale closely interlocking, fully worked out, ruling set of ideas has ever been overthrown. In the way of growth characteristics of this science, variant local states of knowledge and understanding may persist for considerable periods.

This is a fitting place to end, for the analysis of convergence and divergence in the disciplines is an analysis of the growth of science and its ability to cope with the social consequences of its growth. Such questions are inseparable from a study of the academic profession, and in need of answers.

FOOTNOTES

1. Martin Finkelstein, The American Academic Profession (Columbus, Ohio: Ohio State Universtiy Press, 1984): 7-32.

2. The interviews were part of a larger study of the academic profession conducted by The Comparative Higher Education Research Group at UCLA. The sixteen institutions were Stanford; University of Michigan (Ann Arbor); University of North Carolina at Chapel Hill; George Washington University; Southern Illinois University at Carbondale; Kansas State University; California State University at Hayward; Glassboro State College; University of New Orleans; Carleton College; Bowdoin College; Regis College; High Point College; Suffolk Community College; Piedmont Valley Community College; and East Los Angeles Community College.

3. Robert K. Merton, "The Normative Structure of Science," in Robert K. Merton, The Sociology of Science: Theoretical and Empirical Investigations, ed. Norman W. Storer (Chicago: University of Chicago Press, 1973): 267-280.

4. Michael Mulkay, "Some Aspects of Cultural Growth in the Natural Sciences," Social Research 39 (1969): 22-53.

5. Nicholas C. Mullins, "The Development of Specialties in Social Science: The Case of Ethnomethodology," Science Studies 3 (1973):

271; see also "The Development of a Scientific Specialty: The Phage Group and the Origins of Molecular Biology," Minerva 10 (1972): 51-82.

6. Everett Carll Ladd, Jr. "The Work Experience of American College Professors: Some Data and An Argument," Current Issues in Higher Education 1979 (Washington, D.C.: American Association for Higher Education, 1979): 3-12.

7. C. P. Snow, The Two Cultures and the Scientific Revolution (Cambridge: Cambridge University Press, 1959).

8. Jerry C. Gaff and Robert C. Wilson, "Faculty Cultures and Interdisciplinary Studies," Journal of Higher Education 42 (1971): 186-201.

9. For example, Tony Becher, "The Cultural View" in Perspectives on Higher Education: Eight Disciplinary and Comparative Views, ed. Burton R. Clark (Berkeley: University of California Press, 1984): 165-198.

10. Joseph Ben-David, "The Profession of Science and Its Powers," Minerva 10 (1972): 362-383.

11. National Science Foundation, Annual Science and Technology Report to the Congress: 1982, Washington, D.C.: NSF, (1982): 29-30.

12. Cited in Clifford Geertz, "Blurred Genres: The Refiguration of Social Thought" The American Scholar 49 (1980): 176-177.

13. Daniel Kevles, "Annals of Eugenics (Part I)," The New Yorker (October 8, 1984): 51-115.

14. Mullins, "The Development of a Speciality," op. ct.

15. In its annual surveys of doctoral recipients, the National Research Council divides the life sciences into three general categories: biological sciences; health sciences, and agriculture science. In the biological sciences alone are 31 subfields: biochemistry; biophysics; bacteriology; plant genetics; plant pathology; plant physiology; botany (other); anatomy; biometrics and biostatistics; cell biology; ecology; hydrobiology; embryology; endocrinology; entymology; immunology; molecular biology; microbiology and bacteriology; microbiology; neurosciences; nutritional sciences; parasitology; toxicology; human and animal genetics; genetics; human and animal pathology; human and animal pharmacology; human and animal physiology; zoology (other); biological science (general); biological sciences (other). National Research Council, "Summary Report: 1983" (Washington, D.C.: NRC): 47.

16. Joseph Ben-David, "Roles and Innovations in Medicine," American Journal of Sociology 65 (1960): 567.

17. For example, see Clark Kerr, The Uses of the University (New York: Harper & Row, 1963).

18. National Science Foundation, "Characteristics of Doctoral Scientists and Engineers in the United States: 1981," (Washington,

D.C.: NSF, 1982): 92. The 28% figure is only for NIH; when other agencies are included the percentage rises to 51%.

19. James A. Shannon, "Post World War II Developments: 1945-1955," Journal of Medical Education 51 (1976): 15.

20. National Science Foundation, "Characteristics...", p. 94. This figure includes all federal agencies.

21. Dwight Waldo, "Political Science: Tradition, Discipline, Profession, Science, Enterprise,: in Political Science: Scope and Theory, ed. Fred Greenstein and Nelson Polsby (Reading, Mass.: Addison - Wesley, 1975).

22. David Easton, "The New Revolution in Political Science," The American Political Science Review 63 (1969): 1061.

23. Waldo, Political Science...", p. 57.

24. Ibid., p. 72-73.

25. Cited in Mulkay, "Some Aspects of Cultural Growth...", p. 47.

26. Becher, "The Cultural View."

27. Thomas Kuhn, The Structure of Scientific Revolutions, 2nd edition (Chicago: University of Chicago Press, 1970).

28. Horace Freeland Judson, "Reflections on the Historiography of Molecular Biology," Minerva 18 (1980): 420.